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Over the last 8 weeks the Drift Tube Linac (DTL) recovery program has mainly focused on the repair and replacement of DTL 3 and DTL 1 drift tubes, which are the first DTL tanks that will be operated. On December 31st 2002, the SNS Drift-Tube Linac Recovery and Production Plan (SNS document number: 104020000-TR0008-R00) was submitted to the Department of Energy and then closely tracked with weekly progress reports. A new organization, supplemented with up to 40 FTE's, was put in place (mainly in Los Alamos with strong support from the Lab management) to fully engage in this plan and execute it on the timetable outlined in the report. Inevitably the report had some uncertainties e.g., as to when vendors would be able to deliver, other construction difficulties that would be encountered and when exactly the whole testing infrastructure would be in place and functioning.

Today very detailed delivery plans for the remaining components in DTL 3 and DTL 1 exist. Plans for 4,5,6 and 2 are worked out pending details of fabrication contracts and the project expects all components to be delivered to ORNL by the end of this fiscal year. Over the first two months into the delivery plan the recovery team experienced difficulties that are shortly described below. In both cases they are circumvented to meet the project needs. In the case of DTL 3 the "waveguide taper" showed a vacuum leak, that after several attempts, could not be repaired and a new one is under construction while repair efforts continue. In general, all drift tubes that have either Beam Position Monitors (BPMs) or Electromagnetic Dipoles (EMDs) in them, are much more difficult to built. Therefore, it was decided to install so called "dummy drift tubes" that function electrically like the BPM and EMD drift tubes, but do allow either for position measurement or steering. In the schedule they are called out separately and they will be installed into the DTL as soon as they arrive. Testing and commissioning can meanwhile take place on the presently foreseen schedule. A similar change in philosophy applies to the "post coupler". They will be the last pieces to be installed since they have to be precisely machined after tuning of the tanks. After installation and leak checking the tank should be immediately ready for rf conditioning. The detailed schedules have undergone a variety of changes of this sort compared to the original plan and these changes will be explained in this report as well as folded into a new table format with new dates that are shown (in comparison with the former dates).

A very interesting question is, on which basis the schedules were developed and why are these dates achievable. A "lessons learned meeting" based on repair of DTL 3 and rebuilding DTL 1 drift tubes was held. Extrapolating from present experience with the recovery team and the vendors supports these dates. In addition, the SNS DTL drift tube designs have been changed to simplify and improve the reliability of manufacturing and testing processes and all of these processes will have been tried and proven sound in series production of drift tubes. Further schedule confidence is gained from the fact that production of the drift tubes for these final four tanks will utilize multiple vendors that have been qualified by making full fidelity prototypes and that certain portions of the work (brazing, leak checking, final processing prior to shipment, etc.) are under our direct control and supervision. The engagement of sufficient numbers of experienced engineers, designers and technicians to fully plan, monitor, inspect and in some cases do the work also increases confidence. Finally, the fabrication plans and schedules allocate reasonable amounts of time for the activities and do not include the handicap of beginning work without a proven design or finished drawings as was the case in the rebuild of tank one drift tubes. Comparing the ongoing effort to remanufacture tank 1 drift tubes to the plans for tank four drift tubes provides a quantified reason to be more confident about future schedules. To remanufacture 52 tank one drift tubes and six test articles will likely require 22 weeks with the work starting (in mid-November 2002) before all of the recovery team was in place and before all the manufacturing processes were worked out. It is estimated that

tank four hardware (27 drift tubes and 2 test articles) will require about 14 weeks (March 14 through June 20, 2003) and will have the advantage of fully prepared drawings and the use of drift tube body and sleeve parts prepared earlier. Making 50 % fewer drift tubes in 2/3's of the time seems feasible and shouldn't require as many of the expensive and wearing efforts that the rebuild of tank one required. In order to validate the technical quality of the approach and the schedule the external review board (Pierre Grand and a subset of his original team) has been invited again by the SNS/LANL senior team leader Don Rej. The evaluation is attached to this weekly report.

Since most of the DTL 3 components are delivered to ORNL already the table of milestones for this DTL is substantially reduced and only the missing items are tracked. For the drift tubes itself, since most of them are repaired ones as compared to rebuilds, visual inspections shows improper handling, shipping or both, which results in surface damage. While the actual impact on rf and vacuum performance might be negligible, the risk increases under these circumstance and the recovery team has decided that in case DTL 3 does not come up to full voltage within a period of 2 month, rebuilding of the drift tubes is necessary. Typically the conditioning time and the vacuum performance as well as electrical breakdown and resonant electron emission (multipactor) is affected under such circumstance. Countermeasures are investigated to minimize risk.

At Oak Ridge, DTL 3 is meanwhile installed in the tunnel and preparation for drift tube installation is ongoing. The majority of the drift tubes will be installed beginning the week of March 10^{th}. Conditioning (applying rf power to the rf structure) should begin April 18^{th} (15^{th} according to recovery plan). The water cooling systems are checked out and the Vacuum control system as well as the other controls are almost in place. Installing shielding in place for DTL 1 is the last activity before DT installation will begin. DTL tank 1 is set up in RATS and ready to be vacuum checked. In order to meet the commissioning dates for DTL 1 around the clock installation and testing is required and presently foreseen in the detailed schedule.

Finally the new table of milestones is attached. While the black numbers and comments have not changed as compared to the original recovery plan, the blue numbers/comments are the ones that will be reported against beginning last week and the red numbers/comments will be deleted.

Milestone description	Date expected	Number total	Number or % complete	Delta last week
DTL 3 DT's repair	Feb 28th '03	31 25	29 23	18
DTL 3 DT's rebuilt DTL 3 EMDs	Feb 28th '03 Mar 12th '03	0 4	0 4	0
DTL 3 DT's new built DTL 3 Dummies	Feb 28th '03 Mar 12th '03	2 2	0	-1
DTL 3 BPM's	Aug 31st '03	2		
DTL 3 Top hats	Mar 6th '03	100 %		
DTL 3 postcouplers	Mar 6th '03	100 %		
Waveguide taper	Mar 13th '03	1		
DTL 3 installation DTL 3 ready for RF	April 16th '03 April 16th '03	100 %	? /IPS marker DTL045 IPS marker DTL045	0
DTL 1 DT's repair	April 1st '03 Mar 18th '03	7	7	0
DTL 1 DT's rebuilt	April 1st '03 April 17th '03	48	0	0
DTL 1 DT's new built	April 1st '03	4	0	
DTL 1 dummies	Mar 27th '03	4	0	
DTL 1 DT's installed	May 1st '03	100 %		
DTL 1 other parts	April 1st '03	100 %	84%	1%
All DTL 1 parts shipped	April 1st '03 Mai 20th '03	100 %	23%/ IPS marker DTL055	0
DTL 1 installation DTL 1 ready for rf	May 21th '03 May 21th '03	100 %	? / IPS marker DTLINK31	?

(**Color code for the table:** **---** will be deleted in next report; **---** will be inserted new in next report; **---** will stay in next report.)

Follow up Report by Pierre Grand and his team:

Review and Assessment of the
Drift Tube Linac Recovery Plan
Febr. 28, 2003

Background:

In early December 2002, a committee, chaired by Pierre Grand, was convened to review the design and fabrication problems that the Los Alamos National Laboratory faced in the design and construction of a 70 MeV proton linear accelerator. The outcome of that review was reported in a document dated Dec. 3-5, 2002. The review addressed the problems encountered with the fabrication and delivery of tanks 3 and 1 (in that order). Now half way through the planned recovery schedule, a subset of the original committee was reconvened to assess the progress made to date, and to help, if deemed necessary, by recommending actions that might expedite the process.

Subsequent to the December review, the LANL SNS Project developed a detailed recovery plan and schedule establishing firm delivery dates of end of February and early April for tanks 3 and 1 respectively. The project also established adequate QA procedures and travelers to track progress of individual components. The laboratory added upward of 25 engineers and designers to meet the challenge of this ambitious delivery schedule.

This progress report addresses the state of the recovery program as well as its impact on delivery of tanks 2, 4, 5 and 6. Using the December review as a basis for judging progress, and going over the program with the people in the trenches, trying to minimize disruption, we concur with the following:

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DTL Design and Fabrication Processes:

The design changes recommended in December have been implemented nearly across the board. The in-line vacuum valve has been replaced with a bellows sealed stem, stainless steel body. The NEG pumping units remain but can be valved off from the window area for regeneration. The drift tube bore tubes have been eliminated and the body redesigned for simpler fabrication. The cooling tubes on the tanks are now epoxied in place. The alignment top hats have been redone using SS 304. Tolerances have been relaxed where possible, although the continuously varying drift tube face angles have been retained, we have been told that it was too late in the game to make this change. All fabrication processes seem well in hand. A possible exception to this might be the iris wave guide funnel, the latest prototype had a vacuum leak.

The major problem of electron beam welding which started this enquiry has been resolved. A visit to the e-beam facility (ESCO in Concord, CA) demonstrated the following:

1. Weld procedures have been developed and approved for production. The recommended two weld passes have been incorporated in the process, the second pass being a cosmetic surface smoothing procedure. Metallographic analysis shows good penetration and little or no porosity
2. Improved fixtures and related tooling have been developed that improve the positioning accuracy of the weld. Improvements have also been made in the handling and cleanliness of components.
3. Good oversight has been put in place as well as the appropriate paper trail, travelers and QA, to assure welding compliance. This has also been put in place at all other vendors involved in the fabrication process.

CMI, the machine shop responsible for all machining processes, appears to be on top of things. The bottleneck seems to be the drafting procedure in place. A decision was made early in the game to produce a separate drawing for each part and each step in the fabrication process. This puts a production burden on the drafting process. That procedure could have been simplified. Notwithstanding this bottleneck, production of all components is proceeding satisfactorily.

Since the last review, two minor problems are still being addressed: 1. The new SS 304 top hats are copper plated after machining. Copper plating is not adhering properly to the substrate. This is being addressed. However, it is not clear that this copper plating surface is actually required. 2. The drift tube stem end up out of alignment after welding to the drift tube body. A method has been developed to straighten them, and the welding procedure is being reviewed to mitigate the problem.

Management and Schedules:

The project managers and the Los Alamos National Laboratory management are to be commended for acting with urgency after the December review in providing the resources in both manpower and visibility to expedite the recovery process and to attempt to meet the planned delivery schedule. Actually 25 personnel were added to a project from across the laboratory in a very short time. These were all experienced personnel who could contribute to the recovery program with a minimum ramp up.

The detailed plan and delivery schedule developed by the LANL SNS project set delivery dates March 1st for delivery of tank-3 drift tubes, and April 1st for delivery of tank-1 drift tubes. It will not be met. It will be missed by two to three weeks. On reviewing all the fabrication steps, it quickly becomes evident that there are just too many procedures requiring shuffling between vendors adding lost time to the process. The devil is in the details, and with hindsight, one could redesign the drift tube to simplify the fabrication process, however, it is just too late to do that. There is no single step in the process that accounts for this slippage.

Thus, all tank-3 drift tubes should be delivered on or about March 15th, and tank-1 drift tubes April 15th.

QA and oversight procedures:

A global QA traveler was implemented in early February. This is being introduced into the manufacturing vendors processes. Earlier traveler data is being entered to the global traveler to assure consistency of process for all components. It appears that the project oversight at the vendors is adequate at this time.

Fabrication and Delivery Schedules for Tanks 2, 4, 5, and 6 Drift Tubes:

All design changes, processes and procedures developed for tanks 3 and 1 drift tubes have been incorporated as changes for the fabrication of all the remaining drift tubes. Further efficiencies are being gained as drift tubes for tanks 4-6 have been fitted into four families for blank machining, and into nine families for manufacturing steps prior to final contour machining. Lessons learned associated with grouping drift tubes during electron beam welding have been well factored into this decision. This grouping greatly reduces design and fabrication time while eliminating unique manufacturing operations until near the end of the process. We appreciate and acknowledge this effort on the part of the LANL SNS project.

The LANL SNS project is in the process of bidding and negotiating new contracts for the production of these drift tubes. Multiple vendors are being considered. It is a wise decision as

some time may be regained in the process, and we believe that it is also practically required to meet the desired delivery schedule.

Conclusions and Recommendations:

The recovery program is well on its way to full recovery. The project management and personnel have all demonstrated a sense of urgency in producing quality drift tubes and a complete integrated drift tube linac for the SNS. The slip in the desired schedule is bearable if the end result is success.

The Los Alamos SNS project personnel deserve full support from the SNS management in its endeavor to deliver a quality product.

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